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Data-driven remote condition monitoring optimizes offshore maintenance, reduces costs

A case study shows how advanced condition-monitoring technologies—plus analytical expertise—can optimize maintenance of mission-critical equipment in offshore environments, while lowering costs and improving safety.

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As the world's oil and gas industry strives to expand margins by reducing production costs wherever possible, advanced capabilities enabled by the integration and digitalization of upstream operations can help in substantial ways. One prime example is remote condition monitoring (CM) of well-site equipment, especially offshore.

Fig. 1. Aker BP deployed remote CM on its offshore platform, built to develop Ivar Aasen field in the Norwegian North Sea, in an effort to reduce opex costs, increase regularity and improve operations safety.

CM is the data-driven process of tracking performance parameters of equipment. The data are then used to identify any changes from baseline performance benchmarks that could indicate a developing fault in that equipment or their components, such as motors, drives, pumps, gearboxes, rotating shafts and tables.

While used in other industries for years, CM is an emerging trend in oil and gas E&P, as a means to reduce opex costs, increase regularity, and improve operational safety. In fact, those were the objectives behind the 2013 decision by Det norske oljeselskap, now Aker BP (the result of a 2016 merger with BP Norge), to deploy remote CM on the offshore platform that it built to develop Ivar Aasen field in the North Sea, Fig. 1.

With reserves estimated at some 200 MMboe, the platform is situated in the North Sea's far northern reaches, about 180 km off the Norwegian coast and 725 km south of the Arctic Circle. Water depths average 110 m. First oil commenced on Christmas Eve, Dec. 24, 2016.

The acceleration of operational stability was helped in great part by the digital infrastructure—which includes a stimulated process simulator being used to train personnel—and finding good control loop parameters before start-up. Related to that was extensive onshore factory-acceptance testing of all third-party systems prior to final assembly. Today, the platform produces at a maximum capacity of 60,000 bopd from seven wells.

Given the company's publicly stated goal of driving production costs to under $7/bbl, digitalization of its operations is strategically important to achieving that target, despite the extreme challenges and costs of working in treacherous North Sea weather conditions.

REMOTE CONDITION MONITORING

Condition-based maintenance (CBM) supported by remote CM is especially suited for distant offshore applications, particularly when operating in the North Sea.

For starters, the North Sea's cold, harsh marine environment is among the world's most demanding. The platform's equipment is exposed constantly to penetrating, corrosive sea air. That's in addition to the typical, yet severe, mechanical stresses that all platform equipment endures during day-to-day E&P operations, which makes maintenance all the more critical to uptime and productivity.

With digitalization, planners and engineers chose to take a state-of-the-art maintenance approach using, as guiding principles, both the concepts and implementation of CM and CBM in the design, engineering, construction and, later, the operational scheme of the Ivar Aasen platform.

For the operator, CM's logic is as compelling as its economics. Why perform maintenance according to a strict calendar schedule, when CM can show the actual state of the monitored equipment? If equipment is operating well and displays no indication that maintenance is needed, why not extend the maintenance interval and reduce associated costs?

On the other hand, if CM identifies potential trouble before the scheduled maintenance interval, the operator can perform preventive maintenance on the indicated equipment to help avoid the higher costs and consequences of unplanned downtime or production slowdowns. With a CBM model in place, the company aims to conduct maintenance in well-planned, timelier ways, helping to minimize costly helicopter transports and equipment downtime.

SUPPORT FOR LOW-MANNING PLATFORM OPERATIONS

CBM is a contributor to the low-manning platform objective, enabling the operator to reduce manpower offshore and optimize equipment maintenance schedules. In addition, CBM helps to optimize the platform's inventories of spare parts, maintaining inventory levels with greater precision and less "just-in-case" stocks. This frees capital that might otherwise be tied up by the latter approach.

Notably, the operator's decision to completely rethink maintenance early in the design stage shows how its engineers chose to combine advancements from many diverse technologies—in this case, sensors and fiber optics, plus data collection, storage and analytics, among many others—to achieve much more than just doing faster and cheaper maintenance. Instead, they were able to apply the concepts of CM and CBM to the platform's offshore requirements to do maintenance better and smarter, by not waiting for failures to occur and fix but, instead, to predict and prevent them from happening in the first place.

For assistance with this digitalization project, which would span the platform's entire operational life, Siemens was engaged. The actual scope of work was broader than CM-enabled CBM, as the operator wanted to sole-source a fully integrated package of electrical, instrumentation, control and telecom (EICT) functionality—essentially the platform's nervous system. Unifying the EICT helped to significantly minimize project risk by reducing the number of vendors involved, along with their different EICT interfaces. It also simplified and streamlined procurement, integration, testing and support.

As the prime EICT contractor, Siemens worked closely with the engineering team in the design, engineering, fabrication, integration, testing, commissioning and support of this EICT solution, while assuming responsibility for the integration of hardware and software packages from 20 third-party suppliers. Project management, administration, procurement and technical lead engineers for the EICT project execution were stationed in Oslo, Norway, where Siemens has staffed a dedicated team of offshore oil and gas experts.

The EICT package design linked the platform's plant and process designs to the commissioning phase. By integrating the engineering of the design and layout at the basic design stage, Siemens made it easier to identify critical issues and their solutions much earlier in the project. This virtual approach helped optimize design and engineering early on, which preempted later changes. This saved time and improved quality in subsequent project phases. It also created additional savings through better interface coordination and standardization.

In addition, all platform components, modules and systems were standardized as much as possible, to reduce spare parts requirements and maintenance expenses over the platform's 20-year lifecycle. With multiple vendors, interfaces would have proliferated and complicated an already challenging task of training maintenance staff. Therefore, instead of having to learn several different human-machine interface (HMI) and programming systems, the maintenance staff only had to learn one.

GLOBAL COLLABORATION

Project work spanned the globe. The Oslo-based EICT engineering team worked on the basic EICT design, while Siemens Center of Competence in Mumbai, India, completed detailed engineering for the HMI systems. Field instrumentation was developed by Siemens' team in Karlsruhe, Germany. Siemens also was responsible for the standardization and delivery of all low-voltage motors and switchgear to a yard in Singapore, where the platform's entire 15,000-ton topside was fabricated.

The platform's fully integrated EICT package was built on the Siemens SIMATIC PCS 7 process control system with proven oil and gas software code libraries, field instruments, systems for electrical distribution, and telecommunications.

The software stack includes the OSIsoft PI Asset Framework application for real-time operational data gathering from hundreds of CM sensing points connected to rotating equipment, valves, process monitors, electrical equipment, and instrumentation and automation controls, Fig. 2.

Two identical control rooms were built, one offshore on the platform, and the other onshore in Trondheim, Norway, 1,000 km away from the platform. The twin control rooms are linked via redundant, highly secure connections over the Tampnet subsea fiber-optic network that serves the North Sea's E&P operators. Cybersecurity was a paramount concern, addressed by a layered, defense-in-depth approach according to ISA/IEC 62443 and ISO 27001 and 27002, the world's foremost data security standards.

Now in full operation, the platform's equipment is co-monitored from the Trondheim onshore organization, which can use their normal office facilities where the dashboard solutions bring detailed information to the different stakeholders, providing CBM oversight and engineering support. Also, vendors can get access to this solution and support maintenance work. Aboard the platform, the dual control room facilitates visibility, communications and interactions between onboard technicians, who do more hands-on work, and their onshore counterparts, who support them in managing the CM. The jobs of the onshore technicians are much the same as if they were aboard the platform, except they aren't subject to its weather and relative privations.

The platform's CM data analytics use the identical real-time and historical CM data. Data from hundreds of CM telemetric signals are analyzed using Siemens analytic software. Performance metrics, both individual signals and combinations of signals, are compared to baselines for indications of anomalous behavior, such as vibration patterns that deviate from what they should be. Moreover, with a huge installed base of automation systems and electrical components deployed in industries worldwide,

Fig. 2. Siemens' software stack includes the OSIsoft PI Asset Framework application for real-time operational data gathering from hundreds of CM sensing points connected to rotating equipment, valves, process monitors, electrical equipment, and instrumentation and automation controls. A complete list of monitored functions is listed here.

Conditions monitored remotely at the Aker BP Ivar Aasen platform

Rotating equipment
- ☐ Vibration/temperature monitoring
- ☐ Performance monitoring (pumps/compressors)

Valves
- ☐ Valve monitoring (movement/operations)
- ☐ PSV monitoring
- ☐ Valve leakages
- ☐ Partial stroke
- ☐ Shutdown analysis
- ☐ Control valve monitoring

Process
- ☐ Control loop monitoring
- ☐ Heat exchanger

Electrical equipment
- ☐ **UPS:** Performance/batteries
- ☐ **Transformers:** Winding temp/hot spot/load
- ☐ **VSD:** Temperatures/fans/max-min current
- ☐ **HV Switchgear:** Gas condition/unbalance/temperatures/currents
- ☐ **LV Switchgear:** Earth fault/phase loss/current unbalance/wear
- ☐ **HV/LV Breaker:** Unbalance/breaking current/number of operations

Instrument and automation
- ☐ Instrument diagnosis (Hart)
- ☐ Transmitter monitoring
- ☐ ICSS diagnosis: loops, modules, power supplies, servers
- ☐ Computer monitoring
- ☐ Network monitoring: switches/cables
- ☐ Cabinet monitoring: temperatures/MCBs/power supplies/fans
- ☐ Telecom systems monitoring
- ☐ Computers

Siemens has a vast library of established baseline operating signatures for its portfolio of products.

TIME-STAMPING PERFORMANCE EVENTS

Time stamping of performance-related events is a unique Siemens technology deployed inside the CM-based CBM model. Conventional CM methods sample time intervals (e.g., every third second). The problem is, time sampling might catch one anomaly but miss another, especially if multiple events are recorded in one sample. With two or more events occurring in a single sample, it's impossible to know their sequence and, therefore, determine any cause and effect.

With time stamps, however, the sequence of an event series can be seen clearly, making it easier to identify and distinguish correlation and causation. This can accelerate troubleshooting by making data analysis more precise, reliable and insightful. For example, the CM algorithms for On/Off valves monitor the trends in traveling time and can identify early on if a valve starts moving more slowly.

The platform's CBM system also helps the company comply with the Norwegian government's regulations regarding the maintenance of the platform's oil and gas metering system. Annual calibration is required, because this equipment is used in part to determine the revenue split among the platform's partners, as well as taxes owed. With the system consisting of 280 instruments, manual calibration—as done in the past—would consume approximately 40% of an engineer's time each year.

Instead, with CM in place, the company is working with regulators to show them how much it improves the precision, accuracy and efficiency of the metering system's instrumentation. As a result, the company aims to perform the manual calibration once every three years, instead of annually, which allows its engineers to focus on other value-added tasks.

EXPANDING MARGINS, DESPITE FLAT MARKET PRICES

Ultimately, Aker BP envisions normally unmanned, fully automated, onshore-monitored platforms to drive production costs even lower in a not-too-distant future. To this end, the company and Siemens will continue working together to improve platform performance, while also refining their CM-based CBM model for use in other E&P platform projects. The Ivar Aasen platform's high-fidelity process twin that was created during the design and engineering phases will stay viable for the platform's entire lifecycle, and will enable engineers to test ideas for enhancements before committing them to deployment.

This digital lifecycle approach to offshore production assets is now called Topsides 4.0, and allows Siemens to help E&P operators reduce project cycle times, minimize unplanned downtime, and reduce offshore manning for operations and asset monitoring. Underpinned by highly secure communications and centered around core modules of compression, power generation, power distribution and automation, Topsides 4.0 offers a model that was proven in the Ivar Aasen platform's deployment and operation. This model can transform offshore production, with significant upside potential for profit margins, even if prices remain "lower for longer," as many industry analysts anticipate.

Concurring with digitalization's potential for E&P operators is DNV GL, the world's largest technical consultancy to onshore and offshore energy companies. It estimates that the full digitalization of their operations can enable these companies to become at least 20% more efficient than they are today. This payoff will derive from digitalization, providing greater and sometimes unexpected insights that can predict failures ahead of time, so that operators can time interventions more efficiently. WO

MORTEN ILEBY leads maintenance and support for automation and telecom systems on the Ivar Aasen platform. After joining Aker BP in 2012, he led the development within automation and condition monitoring for the Ivar Aasen project. Previously, Mr. Ileby held similar positions at Sevan Marine, Siemens and Eni. Throughout his 30-year career in the oil and gas industry, Mr. Ileby has worked on offshore projects in the UK, Brazil, South Korea and Norway.

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